EA05

Spin Precession in Two-dimensional Electron System

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We study the spatial behavior of spin precession for traversing electrons in a two dimensional system with both the Rashba and Dresselhaus spin-orbit (SO) couplings. Treating the two SO coupling as non-Abelian spin-orbit gauges and performing the unitary gauge transformation for the Hamiltonian, the effect of SO coupling is exactly represented by a spin rotation operator, providing a convenient framework for studying the property of ballistic spin transport. We derive the analytical expression for the spin configuration and demonstrate a classical analog of spin precession. The present approach provides a powerful means, e.g., the spin rotation axis, the precession angle and the cone angle, allowing concrete description of the local spin orientation. In particular, the spatial features such as the specific transport path with null spin precession and the special contour with complete cycles of spin precession can be easily identified.

EA06

Spin-torque Induced RF Oscillations in MgO-based Magnetic Tunnel Junctions

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The spin-torque induced rf oscillation was first observed in all-metal multilayers [1,2], and the mechanism of the magnetization precession has been studied intensively. Recently, the rf oscillations in magnetic tunnel junctions (MTJs) attract much attention due to the large output power of rf signal [3]. However, it has yet to be reached systematical physical understanding because of the complicated spin dynamics, which appears as a complicated shape of the rf spectrum [3]. In this study, we measured the rf oscillation spectra in MgO-based MTJs under the external magnetic field with different angles. We applied the bias current up to 2.5 mA to observe clear rf oscillations and investigated the angular dependence of the intensity, shape, peak frequency, and linewidth.

We fabricated pillar-structured MTJ devices (representative pillar area: 50 × 150 nm^2) consisting of the following layers : substrate / under layers / PtMn / CoFe / Ru / CoFeB / MgO / CoFeB / capping layers, where the top CoFeB layer is the free layer with the thickness of 1.5 nm or 2 nm. In the rf measurement, the relative angle between the free and pinned layer magnetizations (θ)was controlled by changing the angles and magnitude of the external field.

The rf spectra for θ =or 180 degree, which corresponds to the easy magnetization axis for the pillar, show several peaks, as those were previously observed [3]. At θ~20 degree, however, simple lorentzian type power specrtra were observed. Those peak frequencies show the red shift with increasing the bias current. At θ~90 degree, in a low current region the linewidth (full width at half maximum) shows the linear decrease with increasing the curent. Above 1 mA, the decrease of the linewidth deviates from the linear relationship. This deviation indicates the transition from the linear regime of thermally excited precession to the non-linear regime [4].

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REFERENCES

[1] S.I.Kiselev *et al*., Nature 425, 380(2003).
[2] M.Tsoi *et al*., Phys. Rev. Lett. 80, 4281(1998).
[3] A.Deac, *et al*., Nature Phys. (in press).
[4] J.V.Kim *et al*., Phys. Rev. Lett. 100, 167201(2008).